

DYNACOMP

FROG MASTER

FROGMASTER

by

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A Totally New and very Rewarding Game

Here's a totally new concept in computer games. Inside each frog or tadpole on the screen is a primitive brain -- entirely simulated by the computer. This enables the critters to learn, or rather be trained, just like real animals. On the surface, FROGMASTER is a fast-moving, high-concentration, competitive game for one to four players. Underneath, however, it's a fascinating exercise in learning how to use operant conditioning to train animals.

The setting is a "football pond" and the object is to train tadpoles to cross your opponent's goal line. Meanwhile your opponent is training tadpoles to invade your goal line; the first side to score 50 points wins. Left to themselves, the tadpoles dart about randomly, but when you reward them, by pressing the red joystick button, they learn to swim in the right direction. When rewarded, the tadpoles glow with pleasure, squeak with delight, and jump again in the same direction. Rewarding also modifies the dozen primitive brain cells that control each tadpole's behavior. Your aim is to condition these brain cells to turn inept tadpoles into dedicated scorers. Your tadpoles should also be trained to avoid hungry linebackers and a rapacious goalie -- or they will get eaten alive. You can get more challenge by adding walls (which must be penetrated) and metamorphosis -- where tadpoles change into jumping frogs that lay eggs and eat opposing players!

REQUIRED ACCESSORIES

- 16K RAM for cassette version
- 24K RAM for diskette version
- ATARI BASIC*
- One Joystick Controller per player

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* ATARI is a Trademark of Atari Inc.

TABLE OF CONTENTS

	Page
1. How to Play FROGMMASTER	1
2. Getting Started	2
Installation Diagram	2
The First Display Screen	3
Moving the Goalees	4
3. Basic Training	5
4. Game Options	7
Changing Speed	8
Scoring	8
Changing Mode	8
Changing the number of Critters	9
Adding Walls	9
Playing Doubles	10
5. Metamorphosis	11
6. Observing the Learning Process	12
An Experimenters Environment	14
References	14
7. Game Tips	15

1. How to play FROGMASTER

Your mission is get your tadpoles across the opponents goal line.

Left to themselves, the players just dart around at random like so many dumb tadpoles -- but if you reward them just right they will learn to jump in the right direction. It is a matter of timing. You reward them with the red button *just after they move*. Then they glow with pleasure, squeak with delight, and take another jump in the same direction. More than that, they try to figure out what it was that they were doing right when you rewarded them and then they tend to do that particular thing more often. Each critter has a dozen primitive brain cells which control its behavior. Reward them just right and you can train any critter to be a star player.

You win by scoring 50 points.

Tadpoles score 10 points between the goal posts and 5 points outside. However, before they are trained, they just doodle around in centerfield. Your first job is to get them trained. When enemy tadpoles attack your goal line you can rebuff them with your goalie (controlled by your joystick). The goalies may be evaded by using a zig-zag approach or by invading the goal line in two places at once. There is no perfect defence and the only way to win is to train your tadpoles to attack.

And then when you have mastered playing with just tadpoles you can add walls and metamorphosis -- where tadpoles turn into frogs which lay eggs and eat members of the opposing team!

2. Getting Started

Before you start make sure that you have the ATARI BASIC cartridge in the correct cartridge slot. Also plug in one or more joystick controllers into the controller jacks as shown below:

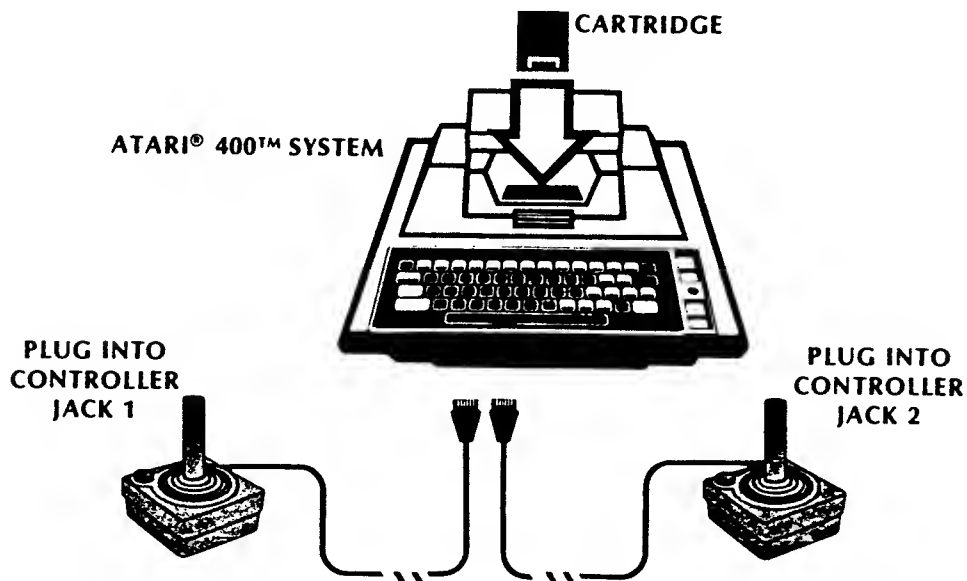


Figure 1. Installation Diagram

If you have the cassette version of the game: *

1. Insert the FROGMASER cassette into the program recorder, press REWIND, and then press PLAY
2. Type CLOAD and then press the return key twice. Wait while the program loads.
3. When you get the READY prompt, type RUN (and press the return key). Loading takes several minutes.

* The cassette version will not fit on a 16K ATARI unless the ATARI is turned on with no disks plugged in.

If you have the diskette version of the game:

1. Insert the game diskette in drive #1. Make sure the drive is on.
2. Power up your ATARI. FROGMMASTER boots automatically.

When the game starts you will see the football pond laid out as illustrated below:

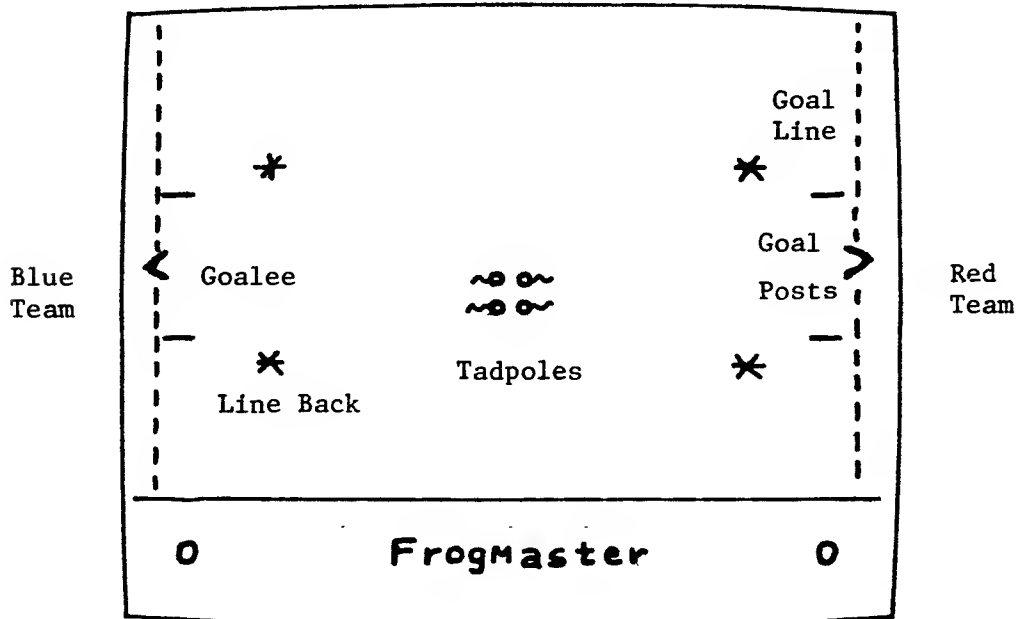


Figure 2. The First Display Screen

The whistle blows. The four tadpoles in the middle of the screen start darting around on their own. On each side there is a goalee and two line backs. The line backs stay where they are and attack any tadpole that comes too close. The goalees move up and down the goal line. You control your goalee with your joystick.

Moving the Goalees

Hold your joystick controller so that the red button is at the top left as shown below:

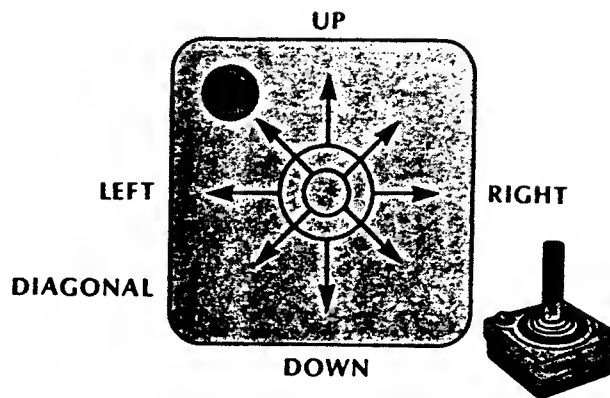


Figure 3. Joystick Moves

Move the joystick in the direction marked UP and one of the goalees will start to move upwards. If the blue goalee on the left moves then you are in charge of the Blue Team whereas if the red goalee on the right moves you are in charge of the Red Team. The goalees only move up and down and moving the joystick sideways has no effect. Thus it is important to hold the joystick controller the right way around or nothing will happen.

The purpose of the goalees is to intercept incoming tadpoles as they try to score by reaching the goal line. The goalees are quite effective against a stright forward attack by a single incoming tadpole but they are usually foiled by a multiple attack or by tadpoles that have been trained to weave.

3. Basic Training

Before you can train your tadpoles to score for you, you will need a little training yourself. Training is not hard, but there is a knack to it. A few moments dedicated practice and it is easily mastered.

Before challenging an opponent, first hone your skills in practice mode. After getting FROGMASTER started:

- . Hit the OPTION button three times to toggle the speed to SLOWEST
- . Press the '1' key to reduce the number of tadpoles to one on each team
- . Press START

These steps make the training process easier to follow.

Now take the joystick controller plugged into controller jack #1. This is the controller for the blue team. Carefully watch the blue tadpole. If it darts to the right, towards the opponents goal line, immediately press the red "reward" button. If you have your timing right the blue tadpole will:

- . momentarily glow with pleasure
- . make a small squeak of delight
- . make an extra jump towards your opponents goal line

If your timing is off, either nothing will happen or the other tadpole will respond which is not what you want.

You will now observe that after you have rewarded your critter a few times it starts to move fairly consistently to the right. Soon it will reach the opposition's goal line and score for you. If you now stop training it, it will keep moving generally to the right and score several more goals. The critters gradually forget what they have been taught and resume moving more or less at random.

To verify that you understand the training process, watch the tadpole that you trained to move to the right and now reward it only when it moves to the left. If you have it well trained, you may have to wait a while before it makes a jump to the left. However, after the first reward, the training goes much faster. As you train it you will notice that it suddenly changes from blue to red. Tadpoles trained to move right are colored blue and those trained to move left are colored red. The tadpoles

have no intrinsic loyalty and may be trained to play for either side. All the tadpoles are potential players for your team no matter which side they happened to start on.

Note that although the joysticks 1 and 2 move different goalees, all the reward buttons act the same and any reward button can reward any tadpole. The effect of pressing the reward button depends entirely on the timing.

When you and your opponent have completed basic training, you can start your first duel. Press RESET and type RUN and the game will restart with two players on each side.

Scoring is easy. Each tadpole scores 5 points plus 5 bonus points for scoring between the goal posts. The first team to score 50 points is the winner.

4. Game Options

Variations on the basic game may be obtained using the following keys:

OPTION	Displays and selects the speed
SELECT	Displays the game mode (e.g. PLAYER vs PLAYER) and lets you select other game modes
START	Restarts the game. Scores are reset and all training is annulled
'P'	Causes the game to pause
RETURN	Restarts play after a pause
'0' - '9'	These keys normally reset the number of players per team. The effect is latent and you may have to also press START. The number keys have a different meaning when DISPLAY is ON
'W'	Toggles WALLS mode ON and OFF. The effect is latent and you must also press START
'D'	Toggles DISPLAY mode ON and OFF. (See Section 5)
'M'	Displays METAMORPHOSIS mode and lets you toggle it ON and OFF. The effect is immediate. When METAMORPHOSIS is ON, tadpoles turn into frogs and frogs lay eggs etc. (See Section 6)
'G'	Displays GAME mode and lets you toggle it ON and OFF.

METAMORPHOSIS and DISPLAY mode are covered in more detail in Sections 5 and 6 respectively. The rest of this section elaborates some of the remaining options.

Changing Speed

There are three speeds -- FULL SPEED, SLOW, and SLOWEST. The default setting is SLOW. SLOWEST is recommended for beginners and FULL SPEED is for experts who find the SLOW setting too sluggish.

When you press the OPTION key once, the current speed is displayed in the middle of the bottom panel. Additional presses cycle the speed through the three options. The game will resume automatically after a modest delay -- if you are in a hurry, press RETURN and play will resume at once.

Scoring

50 points are needed to win. In the standard game, tadpoles score 5 points for reaching the goal line plus 5 bonus points for scoring between the goal posts.

In the advanced game, with METAMORPHOSIS set ON, the scoring mimics football. Tadpoles always score 3 points. Frogs score 6 points plus an extra point for "conversion" if they score between the goal posts.

Changing Mode

Hitting the SELECT button once causes the current mode to display on the bottom panel. Additional presses cycle you through the following alternative modes:

player vs player
player vs player (handicap)
computer (handicap) vs player
computer vs player
player vs computer
player vs computer (handicap)
player (handicap) vs player

The game will resume automatically after a delay. You may resume play at once by hitting the RETURN key.

The effect of a handicap is to add a sort of tilt to the game so that the critters have a bias towards moving towards the handicapped players goal line. The handicapped player has to train his players harder to produce a given effect.

When playing the computer, a similar tilt is introduced biasing the game against the human player. If you play the computer with a handicap the bias is moderate. Beating the computer without a handicap requires considerable concentration. When you play the computer you will notice its goalkeeper moving into position automatically as you approach. Just like human opponents the computer may be foiled by weaving and by attacking on both ends of the goal line at once. FROGMASTER was not designed as a one person game and you will find it most exciting when you match wits with a real human opponent.

Changing the Number of Critters

You may change the number of critters on each team by hitting one of the number keys '0' through '9' and then pressing START.

When the DISPLAY mode is ON these keys have a different meaning. You must toggle DISPLAY mode OFF before resetting the number of critters.

When METAMORPHOSIS is ON, it is not necessary to restart the game. Since, in this mode, critters are always dying and laying eggs, the number of active critters is constantly changing. The effect of resetting the nominal number of critters is an adjustment of the birth and death rates to keep the actual number in the general range that you specified. For example if you start with 2 critters per team and then press the '5' key, the number of critters will gradually increase to average around 10.

Adding Walls

To add to the challenge of the game you may create a pair of walls lying between the line backs and the goalie on each side. If you press the 'W' key once, the bottom panel will tell you if WALLS are ON or OFF. Pressing the 'W' key a second time toggles WALLS mode to the opposite state. You must then press START to restart the game with the selected setting.

When a tadpole rams into a wall it may either rupture the wall or just bounce off it. This behavior, like almost everything in FROGMASTER, may be influenced by training. Clearly you want to reward your own tadpoles for annihilating walls while rewarding your opponent's tadpoles when they bounce off.

Frogs also bounce off walls but they can leap over them if they jump high enough (another property subject to training). If you reward your opponent's frog for bouncing off a wall, you will make it harder for that frog to get over in the future and you will also give it a boost towards your opponent's goal line.

Playing Doubles

To play FROGMASTER with four players, plug in two additional joystick controllers into controller jacks 3 and 4. The joysticks on these controllers have no effect and you must use the joysticks on controllers 1 and 2 to control the goalees (as before). The reward buttons on controller jacks 3 and 4 behave exactly like those on controllers 1 and 2.

Normally one player on each team will play defence and operate the goalee, while the other player concentrates on rewarding. However there is nothing to prevent with the defender from rewarding and helping out on the attack side. A critter may be rewarded twice in one cycle if he is rewarded successively by two *different* players.

It is important to understand that *all* the reward buttons do *exactly* the same thing -- just as if they were physically wired together. All the critters respond to a reward in exactly the same way -- no matter where it comes from. Thus it does not matter who has which joystick controller as long as the defenders on each team use controllers 1 and 2.

5. METAMORPHOSIS

When you have mastered the basic form of the game, you can add some more excitement by switching METAMORPHOSIS to ON. Metamorphosis is the technical name for the process by which tadpoles turn into frogs and catapillars turn into butterflies. It literally means change-form from the Greek (META=Change, MORPHO=Form). In FROGMASTER tadpoles metamorphose into frogs, frogs lay eggs, and eggs hatch to make new tadpoles. The invention of birth required the invention of death or else the number of critters would increase to fill the whole screen. Thus, when METAMORPHOSIS is ON, frogs die of old age and eat players on the opposing team. The line backs and goalees no longer just spit out critters they catch -- now they swallow them whole.

The current state may be found by pressing the 'M' key once. If the key is pressed a second time it will toggle the state to the other setting.

When METAMORPHOSIS is on, the scoring is slightly different. Tadpoles always score 3 points. Frogs score 6 points plus a bonus point for 'conversion' if they score between the goal posts. You still need 50 points to win.

FROGMASTER critters breed asexually. Only one frog is required to lay an egg. In real life, all higher animals breed sexually and both a male and a female are required to produce offspring. This is so that the genetic traits from the two parents can be recombined. In FROGMASTER the learned habits of the parent are passed on to each egg. This form of inheritance, known as Lamarkism, after the French Biologist Lamark, does not occur in the real world -- despite the fact that it is part of traditionally communist dogma to believe that it does. Whereas FROGMASTER presents a reasonable simulation of operant conditioning, it presents an inaccurate model of natural selection.

What this means in actual play, is that once you have a well trained frog, you can then breed up a whole clone of similarly trained critters to storm your opponents lines.

The breeding process itself is subject to training. If we reward an egg for hatching, its descendants will hatch faster. If we reward a tadpole for metamorphosing, its descendants will metamorphose faster. If we reward a frog for becoming pregnant (pregnant frogs bounce up and down), that frog will become pregnant more often. With patience we can breed a population that is either all frogs, all eggs, or all tadpoles. Note that only transitions are subject to training. The reward must be made immediately after the transition or it has no effect.

6. Observing the Learning Process

Each FROGMASTER critter has a primitive brain consisting of twelve identical nerve cells (or neurons). Each neuron is arbitrarily wired to one of the twelve variables which control how the critter moves and changes form. Each neuron is capable of the very simplest response to a reward.

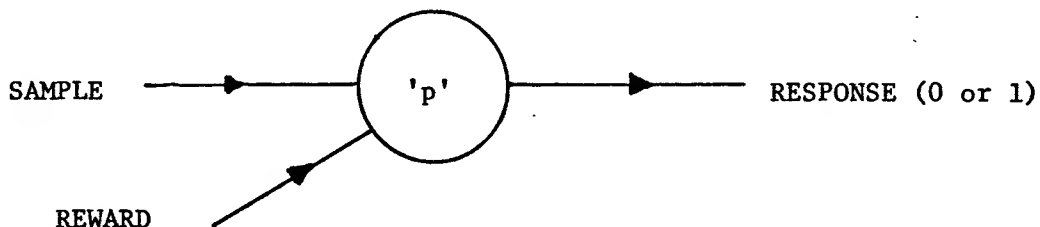


Figure 4. Diagram of a Nerve cell

When some specific behavior is desired (e.g. move left or move right), the neuron is sampled and produces a binary response (0 or 1) with a probability 'p'. If the response is immediately followed by a reward, the probability 'p' increases if the neuron had just responded with a 1 and decreases if the neuron had just responded with a 0. This is called positive reinforcement. If the neuron is sampled and no reward follows, 'p' changes by a much smaller amount in the opposite direction. This is known as forgetting or 'extinction'.

This simple type of learning behavior is known as operant or instrumental conditioning. It occurs in real creatures throughout the animal kingdom right up to and including man. Human brains are far more complex. The human brain contains in excess of 100 trillion cells -- each one of which is far more elaborate than those found in *Frogus Electronicus*. Yet the underlying mechanism is universal. Traditionally operant conditioning has been studied in rats and pigeons using a Skinner box. It is the method used to train performing seals and circus animals. Those clever tricks performed by animals on TV and in the movies are produced by operant conditioning. When the animal does the right thing a clicker is sounded to indicate that it has earned a fish or seed or whatever morsel of food is appropriate. Training is accomplished in stages. The trainer becomes gradually more specific about the behavior he rewards. This approach should also be used with FROGMASTER critters.

To observe the learning process we can place a 'probe' into the head of any given critter on the screen and watch just what goes on as we modify its behavior. This is done by pressing the 'D' key, which sets DISPLAY mode ON. When we press the key, one of the critters on the screen will light up to show us which one we are observing. Hitting one of the number keys changes the critter that is being probed. By trial and error we can find the critter that we want to follow. If no critter lights up it means that we have selected a critter that is not currently active and should try again.

When we go into DISPLAY mode, the bottom panel changes to the following form:

```

47 57 51 80 40 55
'x'  'y'  wv db

```

Figure 5. Probabilities displayed with METAMORPHOSIS off

Six neurons control the basic movements. The pairs marked 'x' and 'y' control the basic direction of movement. The left number in each pair shows the probability of moving at all on that axis, and the second numbers shows the direction (left/right or up/down) to move if a movement occurs. In the example, we see that the selected critter has a 51% chance of moving in the y-direction and that if it moves it has an 80% chance of moving up rather than down.

In competitive play, cell #2, which controls left versus right, is the most important cell to train. Cells #5 and #6, which control weaving and double jumping, are also important to train. Double jumping gets the critter to the goal faster and zig-zagging is important for evading the opponents goalee.

When WALLs are in use, two more neurons come into play. One controls whether tadpoles drill through the walls and the other controls whether frogs jump over the walls. The relevant probability is displayed in the top right of the panel and indicated by a section of wall. Notice that probability only changes when the critter jumps against a wall.

METAMORPHOSIS brings the four final neurons into play. One is used to permit frogs to make extra long jumps (two squares left or right in a single hop). The probability for this is shown at the bottom left under the 'x'. The other three control the transitions between different stages of the life cycle. The probabilities are displayed at the bottom of the panel.

As you can discover by experimentation, rewarding a neuron causes an immediate change in the displayed probabilities, either up or down, of perhaps 20%. The higher the value of 'p' the smaller the increase. The change is of such a magnitude that random reinforcement produces an expected change of zero.

If no reward is given the probabilities move by a small amount towards 50%. Some of the probabilities may remain unchanged. A cell's state is changed only when the behavior it produces is manifest. For example, if there is no movement in the x-direction (cell #1 signals 0) then the effect of cell #2 (controlling left/right) is masked. Cell #2 is therefore not manifest and its value of 'p' is not affected by the giving or withholding of reward in that cycle.

Reinforcement affects all cells that are manifest in a like manner. If you focus on how the critter moves in the x-direction and ignore how it moves in the y-direction, cells #3 and #4 will still be reinforced, albeit at random. Normally their probabilities will drift up and down. On the average they should stay constant but in any given experiment it is unlikely that they end up just where they started. On the contrary, it may happen, by chance, that a series of 'random' reinforcements all add up to produce a significant change in 'p'. Just by chance we should expect such accidental runs to occur every so often. This effect may be observed in training animals and is known as 'superstition'.

An Experimenters Environment

FROGMMASTER has many frills to make a more exciting game. For example, a reward causes an extra jump, and critters must always move. By pressing the 'G' key and toggling GAME to OFF, we may suppress these extras. If you restart the game with GAME off, the line backs, goalees, and goal line will not appear. Thus you may obtain an empty tank in which training may be studied without distractions.

References

Those interested in understanding operant conditioning in more depth may find more information in any major psychology text. The following books are recommended:

1. "Introduction to Psychology" by Hilgard, Atkinson, and Atkinson (See Chapter 7).
2. "Introduction to Modern Behaviorism" by Howard Rachlin.

7. Game Tips

ATTACK

There is no perfect defence in FROGMASTER. If you do not train your tadpoles to attack and score, you must eventually lose.

TRAIN YOUR CRITTERS TO WEAVE

The goalees are very good at stopping a critter coming in straight. Train your critters to weave. In Soccer your best chance to score is to go for the corners of the goal. In FROGMASTER you must shoot an angle to foil the goalee.

SPEED UP GOOD PLAYERS

Once you have a player going in the right direction, speed him up. Reward double jumps and long jumps(frogs only). The faster they come the more often they score and the harder they are to intercept.

UNTRAIN YOUR OPPONENTS PLAYERS

Reward your opponents critters when they move your way or bounce off a wall. Encourage them to make straight single jumps.

DRIVE YOUR OPPONENT INTO YOUR GOALEE

Always be ready to give your opponent a push into the deadly embrace of your goalee or a line back. Give your own frogs a push if the extra hop will land them on one of your opponents critters.

DEVELOP PERIPHERAL VISION

Try and watch all the critters on the screen simultaneously. The more you practice the better able you are to do this.

And remember, when it gets too easy you can set the speed to maximum and add more critters.

Game Options

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